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MOLDED WOOD FLAKE ARTICLE WITH INTEGRAL FLEXIBLE SPRING MEMBER

BACKGROUND OF THE INVENTION

Wood flake molding, also referred to as wood strand molding, is a technique invented by wood scientists at Michigan Technological University during the latter part of the 1970s for molding three-dimensionally configured objects out of binder coated wood flakes having an average length from about 1¼ to about 6 inches, preferably from about 2 to about 3 inches; an average thickness of about 0.005 to about 0.075 inches, preferably from about 0.015 to about 0.030 inches; and an average width of 3 inches or less, most typically 0.25 to 1.0 inches, and never greater than the average length of the flakes. These flakes are sometimes referred to in the art as "wood strands." This technology is not to be confused with oriented strand board technology (see e.g., U.S. Patent No. 3,164,511 to Elmendorf) wherein binder coated strands of wood are pressed into planar objects. In wood flake or wood strand molding, the flakes are molded into three-dimensional, i.e., non-planar, configurations.

In wood flake molding, flakes of wood having the dimensions outlined above are coated with methylene diisocyanate (MDI) or similar binder and deposited onto a metal tray having one open side, in a loosely felted mat, to a thickness eight or nine times the desired thickness of the final part. The loosely felted mat is then covered with another metal tray, and the covered metal tray is used to carry the mat to a mold. (The terms "mold" and "die", as well as "mold die", are sometimes used interchangeably herein, reflecting the fact that "dies" are usually associated with stamping, and "molds" are associated with plastic molding, and molding of wood strands does not fit into either category.) The top metal tray is removed, and the bottom metal tray is then slid out from underneath the mat, to leave the loosely felted mat in position on the bottom half of the mold. The top half of the mold is then used to press the mat into the bottom half of the mold at a pressure of approximately 600 psi, and at an elevated temperature, to "set" (polymerize) the MDI binder and to compress and adhere the compressed wood flakes into a final three-dimensional molded part. The excess perimeter of the loosely felted mat, that is, the portion extending beyond the mold cavity perimeter, is pinched off where the part defining the perimeter of the upper mold engages the part defining the perimeter of the lower mold cavity. This is sometimes referred to as a pinch trim edge.

[0003] U.S. Patents 4,440,708 and 4,469,216 disclose this technology. The drawings in Patent U.S. 4,469,216 best illustrate the manner in which the wood flakes are deposited to form a loosely felted mat, though the metal trays are not shown. By loosely felted, it is meant that the wood flakes are simply lying one on top of the other in overlapping and interleaving fashion, without being bound together in any way. The binder coating is quite dry to the touch, such that there is no stickiness or adherence which hold them together in the loosely felted mat. The drawings of Patent U.S. 4,440,708 best illustrate the manner in which a loosely felted mat is compressed by the mold halves into a three-dimensionally configured article (see Figs. 2-6, for example).

[0004] The above described process is a different molding process as compared to a molding process one typically thinks of, in which some type of molten, semi-molten or other liquid material flows into and around mold parts. Wood flakes are not molten, are not contained in any type of molten or liquid carrier, and do not "flow" in any ordinary sense of the word. Hence, those of ordinary skill in the art do not equate wood flake or wood strand molding with conventional molding techniques.

[0005] It has been discovered that wood flake molded parts have a very well defined spring constant. Sections of molded wood flake articles having a thickness of 1/2, 9/16, and 5/8 inches and a width of 2 inches and an effective length of 16 inches were mounted to define a cantilevered spring and were tested. It was discovered that the spring constant for the respective thickness of 1/2 inch was 10 pounds per inch deflection; 9/16 inch was 11 pounds per inch deflection; and 5/8 inch thick was 14 pounds per inch deflection. It was further discovered that the molded wood flake spring so formed returned to its original position within two minutes of a load being removed and displays only a 5 percent to 8 percent hysteresis over time. In view of the fact that the molded wood flakes can be formed in any desired three-dimensional configuration, this discovery allows the material to be used for deflectable weight supporting articles, such as in the seating environment. A clear benefit of using such spring material as opposed to typical coil springs or sinuous wire springs is that they are not subject to rust nor do they require the intense labor necessary when manufacturing a chair or other seating object utilizing conventional springs. Further, the feel of the seat utilizing such springs is improved inasmuch as the springs do not require preloading, as with typical sinuous or coil springs. Thus, the use of molded wood flake springs will revolutionize

the manufacture of supports which, in past years, required the use of sinuous or coil springs.

SUMMARY OF THE INVENTION

[0006] In the present invention a molded wood flake support article includes at least one flexible spring. The support may include a plurality of integral spaced-apart linearly extending springs with second ends opposite said first ends that are free to flex, wherein the support is coupled to a frame member. In one embodiment, a plurality of spaced-apart linearly extending spring members are integrally formed from a connecting end piece. The end piece can, in one embodiment, be a curved edge of a seat frame. In one embodiment, an elastomeric mesh is coupled over free ends of the spring members to loosely interconnect the ends of said springs. In yet another embodiment, a seat is formed employing a plurality of spaced-apart linearly extending spring members integrally formed with one end of the seat base having sides coupled thereto, and an elastomeric web extends between the sides underlying said spring members to limit their deflection. In one embodiment also, the elastomeric web can be vertically and horizontally adjusted on the base with respect to the spring members to change the deflection characteristics of said spring members and, thus, the feel of the seat so-formed.

[0007] These and other features, advantages and objects of the present invention will be further understood and appreciated by those skilled in the art by reference to the following specification, claims and appended drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] Fig. 1 is a perspective view of a chair with a plurality of flexible spring members disposed on a back thereof according to one embodiment of the present invention;

[0009] Fig. 2 is a fragmentary front view, partly in cross section, of a molding apparatus with a wood flake mat positioned therebetween before compression;

[0010] Fig. 3 is a view of the molding apparatus of Fig. 2, shown during compression;

[0011] Fig. 4 is a perspective view of the chair back of Fig. 1;

[0012] Fig. 5 is a perspective view of a chair seat with a plurality of flexible spring members according to one embodiment of the present invention;

[0013] Fig. 6 is a perspective view of a chair body according to another embodiment;

[0014] Fig. 7 is a perspective view of a chair according to yet another embodiment;

[0015] Fig. 8 is a left side elevational view of the chair of Fig. 7, illustrating the deflection of the chair back and flexible spring member;

[0016] Fig. 9 is a perspective view of the chair back of Fig. 7 including a foam lumbar support and foam covering;

[0017] Fig. 10 is a perspective view of a chair according to another embodiment of the present invention;

[0018] Fig. 11 is a left side elevational view of the chair of Fig. 10;

[0019] Fig. 12 is a perspective view of a chair according to yet another embodiment of the present invention;

[0020] Fig. 13 is a perspective view of a sofa, partly in phantom form, wherein the sofa back includes a plurality of flexible spring members according to another embodiment of the present invention;

[0021] Fig. 14 is a left side elevational view of the sofa back of Fig. 13;

[0022] Fig. 15 is an exploded perspective view of a chair body of an alternative embodiment of the present invention;

[0023] Fig. 16 is a perspective view of the chair body shown in Fig. 15;

[0024] Fig. 17 is a perspective view of an alternative embodiment of the chair body shown in Figs. 15 and 16;

[0025] Fig. 18 is an exploded perspective view of another embodiment of the chair body of the type shown in Figs. 15 and 16;

[0026] Fig. 19 is a perspective view of yet another embodiment of the chair body shown in Figs. 15 and 16;

[0027] Fig. 20 is a cross-sectional view of the chair body of Fig. 19, taken along section line XX-XX in Fig. 19;

[0028] Fig. 21 is an exploded perspective view of yet another embodiment of the chair body shown in Figs. 15 and 16;

[0029] Fig. 22 is a left side elevational assembled view of the chair body shown in Fig. 21;

[0030] Fig. 23 is a pictorial view of an adjustable structure for the support web shown in the chair body of Figs. 21 and 22;

[0031] Fig. 24 is a perspective view of an alternative embodiment of a chair body; and

[0032] Fig. 25 is an enlarged cross-sectional view of one of the spring members of the chair body of Fig. 24, taken along section lines XXV-XXV of Fig. 24.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0033] For purposes of description herein, the terms "upper," "lower," "right," "left," "rear," "front," "vertical," "horizontal," and derivatives thereof shall relate to the invention as orientated in Fig. 1. However, it is to be understood that the invention may assume various alternative orientations, except where expressly specified to the contrary. It is also to be understood that the specific devices and processes illustrated in the attached drawings, and described in the following specification are simply exemplary embodiments of the inventive concepts defined in the appended claims. Hence, specific dimensions and other physical characteristics relating to the embodiments disclosed herein are not to be considered as limiting, unless the claims expressly state otherwise.

[0034] In a preferred embodiment of the present invention, a molded wood flake article (Fig. 1), such as the back 12 of a chair 10, is fabricated to include a plurality of spaced-apart flexible spring members 14, wherein the flexible spring members can flex independently. In the preferred embodiment, the flexible spring members 14 are integrally molded into support 12 during the fabrication process thereof and integrally extend from a base section 16 of the seat back 12 in a comb-like configuration, as seen in Fig. 4.

PROCESS DETAILS:

[0035] As best illustrated by Fig. 2, in wood flake or wood strand molding the flakes are molded into three-dimensional, non-planar, configurations by utilizing a mold 20 which forms wood flakes 22 into a molded wood flake part, such as part 12. Mold 20 includes a top mold die 26 and a bottom mold die 28. The top mold die 26 includes a surface 21 and at least one extension 23 extending from the surface 21 for forming slots 18 (Fig. 1) which define the perimeter of flexible spring members 14. The bottom mold die 28 includes a surface 25 having at least one extension receiving cavity 27. The surface 21 of the top mold die 26 and the surface 25 of the bottom mold die 28 define a part forming cavity 30 therebetween which forms part 12 into a desired shape, while extension 23 is configured to extend through molded wood flake part 12 and into cavity 27 to form slots 18, thereby defining at least one flexible spring member 14 which can

flex independently from the molded wood flake support or part 12 as illustrated in Fig. 1. Of course, slots 18 may be fabricated by other methods including sawing, cutting, machining and the like.

[0036] As illustrated by Figs. 2-3, the molded wood flake part 12 is made by positioning a loosely felted mat 32 of wood flakes 22 on the bottom mold die 28. The top mold die 26 and the bottom mold die 28 are then brought together or closed, wherein heat and pressure are applied to felted mat 32. Felted mat 32 is thereby compressed and cured into the molded wood flake part 12 having flexible spring member 14 formed therein. In the preferred embodiment, this is accomplished by having extension 23 pass, cut or push through mat 32, forcing wood flakes 22 down into extension receiving cavity 27 to form slots 18. Although only one extension 23 is shown in the illustrated example, a plurality of spaced-apart extensions and cavities are typically used to form a plurality of spaced-apart flexible spring members 14 as illustrated in Fig. 1.

[0037] The molded wood flake part 12 may include additional features such as "T" nut fastener holes 34 (Fig. 4). For example as Figs. 2-3 illustrate, an extension 36 may be used to make hole 34 and is received within cavity 33. The resulting hole 34 provides a uniform appearance from the surface of the molded wood flake part and facilitates the insertion of a T-nut (not shown) from either surface with its mounting flange and associated bar resting on a surface of the molded wood flake part which has been formed, and with its threaded sleeve projecting inwardly into the hole 34. The width of the hole 34 is sufficiently great throughout its length that it will accommodate a sleeve of a T-nut or other item to be inserted into the hole 34, without interference.

[0038] As seen in Fig. 3, the top surface 35 of the molded wood flake part 12 is adjacent the surface 21 of the top mold die 26 and the bottom surface 37 of the molded wood flake part 12 is adjacent the surface 25 of the bottom mold die 28 after the wood flakes 22 have been consolidated, compressed and cured into the molded wood flake part 12. The molded wood flake parts 12 made in this manner will preferably have a nominal thickness T of from about 3/8 inch to about 5/8 inch. Felted mat 32, however, will be compressed to varying thicknesses by mold 20, due to unavoidable inconsistencies of mat 32, such as spring back of the mat, over-compression, or the like. Therefore, the bottom surface 37 of molded wood flake part 12 will be located within a zone of variation in part thickness. The zone of variation in part thickness is the area in which the bottom surface 37 of the molded wood flake part 12 could be located,

depending on the thickness of the molded wood flake part 12, compared to a stationary position for the top surface 35 of the molded wood flake part 12.

[0039] The wood flakes 22 used in creating the molded wood flake part 12 can be prepared from various species of suitable hardwoods and softwoods. Representative examples of suitable woods include aspen, maple, oak, elm, balsam fir, pine, cedar, spruce, locust, beech, birch and mixtures thereof, although aspen is preferred.

[0040] Suitable wood flakes 22 can be prepared by various techniques. Pulpwood grade logs, or so-called round wood, are converted into wood flakes 22 in one operation with a conventional roundwood flaker. Logging residue or the total tree is first cut into fingerlings having an average length from about 1¼ to about 6 inches, preferably from about 2 to about 3.5 inches with a device, such as the helical comminuting shear disclosed in U.S. Patent No. 4,053,004, and the fingerlings are subsequently flaked in a conventional ring-type flaker. Roundwood wood flakes generally are higher quality and produce stronger parts because the lengths and thickness can be more accurately controlled. Also, roundwood wood flakes tend to be somewhat flatter, which facilitates more efficient blending and the logs can be debarked prior to flaking which reduces the amount of less desirable fines produced during flaking and handling. Acceptable wood flakes can be prepared by ring flaking fingerlings. This technique is more readily adaptable to accept wood in poorer form, thereby permitting more complete utilization of certain types of residue and surplus woods.

[0041] Irrespective of the particular technique employed for preparing the wood flakes 22, the size distribution of the wood flakes 22 is quite important, particularly the length and thickness. The wood flakes should have an average length from about 1¼ to about 6 inches, preferably from about 2 to about 3½ inches; an average thickness of about 0.005 to about 0.075 inches, preferably from about 0.015 to about 0.030 inches and more preferably about 0.0020 inch; and an average width of 3 inches or less, most typically 0.25 to 1.0 inches, and less than the average length of the flakes. In any given batch, some of the wood flakes 22 can be shorter than 1¼ inch, and some can be longer than 6 inches, so long as the overall average length is within the above range. The same is true for the thickness.

[0042] The presence of major quantities of wood flakes 22 having a length shorter than about 1¼ inch tends to cause the felted mat 32 to pull apart during the molding step. The presence of some fines in the felted mat 32 produces a smoother surface and, thus,

may be desirable for some applications so long as the majority of the wood flakes, preferably at least 75 percent, is longer than 1 1/8 inch and the overall average length is at least 1 ¼ inch.

[0043] Substantial quantities of wood flakes 22 having a thickness of less than about 0.005 inches should be avoided, because excessive amounts of binder are required to obtain adequate bonding. On the other hand, wood flakes 22 having a thickness greater than about 0.075 inch are relatively stiff and tend to overlie each other at some incline when formed into the felted mat 32. Consequently, excessively high mold pressures are required to compress the wood flakes 22 into the desired intimate contact with each other. For wood flakes 22 having a thickness falling within the above range, thinner ones produce a smoother surface while thick ones require less binder. These two factors are balanced against each other for selecting the best average thickness for any particular application.

[0044] The width of the wood flakes 22 is less important. The wood flakes 22 should be wide enough to ensure that they lie substantially flat when felted during mat formation. The average width generally should be about 3 inches or less and no greater than the average length. For best results, the majority of the wood flakes 22 should have a width of from about 0.25 to about 1.0 inches.

[0045] The blade setting on a flaker can primarily control the thickness of the wood flakes 22. The length and width of the wood flakes 22 are also controlled to a large degree by the flaking operation. For example, when the wood flakes 22 are being prepared by ring flaking fingerlings, the length of the fingerlings generally sets the maximum lengths. Other factors, such as the moisture content of the wood and the amount of bark on the wood affect the amount of fines produced during flaking. Dry wood is more brittle and tends to produce more fines. Bark has a tendency to more readily break down into fines during flaking and subsequent handling than wood.

[0046] While the flake size can be controlled to a large degree during the flaking operation as described above, it usually is necessary to use a screening process in order to remove undesired particles, both undersized and oversized, and thereby ensure the average length, thickness and width of the wood flakes 22 are within the desired ranges. When roundwood flaking is used, both screen and air classification usually are required to adequately remove both the undersize and oversize particles, whereas fingerling wood flakes usually can be properly sized with only screen classification.

[0047] Wood flakes from some green wood can contain up to 90 percent moisture. The moisture content of the mat must be substantially less for molding as discussed below. Also, wet wood flakes tend to stick together and complicate classification and handling prior to blending. Accordingly, the wood flakes 22 are preferably dried prior to classification in a conventional type drier, such as a tunnel drier, to the moisture content desired for the blending step. The moisture content to which the wood flakes 22 are dried usually is in the order of about 6 weight percent or less, preferably from about 2 to about 5 weight percent, based on the dry weight of the wood flakes 22. If desired, the wood flakes 22 can be dried to a moisture content in the order of 10 to 25 weight percent prior to classification and then dried to the desired moisture content for blending after classification. This two-step drying may reduce the overall energy requirements for drying wood flakes prepared from green woods in a manner producing substantial quantities of particles which must be removed during classification and, thus, need not be as thoroughly dried.

[0048] To coat the wood flakes 22 prior to being placed as a felted mat 32 within the cavity 30 of mold 20, a known amount of the dried, classified wood flakes 22 is introduced into a conventional blender, such as a paddle-type batch blender, wherein predetermined amounts of a resinous particle binder, and optionally a wax and other additives, is applied to the wood flakes 22 as they are tumbled or agitated in the blender. As such, the article fabricated from wood flakes 22 is substantially rather than entirely comprised of wood flakes, as other additives as described above are added to create mat 32. Of course, other base materials may also be added to the wood flakes to form a mat 32 comprising a blend of wood flakes 22 and other suitable materials. Suitable binders include those used in the manufacture of particle board and similar pressed fibrous products and, thus, are referred to herein as "resinous particle board binders." Representative examples of suitable binders include thermosetting resins such as phenolformaldehyde, resorcinol-formaldehyde, melamine-formaldehyde, urea-formaldehyde, urea-furfuryl and condensed furfuryl alcohol resins, and organic polyisocyantes, either alone or combined with urea- or melamine-formaldehyde resins.

[0049] Particularly suitable polyisocyanates are those containing at least two active isocyanate groups per molecule, including diphenylmethane diisocyanates, m- and p-phenylene diisocyanates, chlorophenylene diisocyanates, toluene di- and triisocyanates, triphenylmethene triisocyanates, diphenylether-2,4,4'-triisoccyanate and

polyphenylpolyisocyanates, particularly diphenylmethane-4,4'-diisocyanate. So-called MDI is particularly preferred.

[0050] The amount of binder added to the wood flakes 22 during the blending step depends primarily upon the specific binder used, size, moisture content, type of the wood flakes and the desired characteristics of the part being formed. Generally, the amount of binder added to the wood flakes 22 is from about 3 ½ to about 15 weight percent, preferably from about 4 to about 10 weight percent, and most preferably about 5 percent. When a polyisocyanate is used alone or in combination with a urea-formaldehyde resin, the amounts can be more toward the lower ends of these ranges.

[0051] The binder can be admixed with the wood flakes 22 in either dry or liquid form. To maximize coverage of the wood flakes 22, the binder preferably is applied by spraying droplets of the binder in liquid form onto the wood flakes 22 as they are being tumbled or agitated in the blender. When polyisocyantes are used, a conventional mold release agent preferably is applied to the die or to the surface of the felted mat prior to pressing. To improve water resistance of the part, a conventional liquid wax emulsion is also sprayed on the wood flakes 22 during the blinding step. The amount of wax added generally is about 0.5 to about 2 weight percent, as solids, based on the dry weight of the wood flakes 22. Other additives, such as one of the following: a coloring agent, fire retardant, insecticide, fungicide, mixtures thereof and the like may also be added to the wood flakes 22 during the blending step. The binder, wax and other additives, can be added separately in any sequence or in combined form.

[0052] The moistened mixture of binder, wax and wood flakes 22 or "furnish" from the blending step is formed into a loosely-felted, layered mat 32, which is placed within the cavity 30 prior to the molding and curing of the felted mat 32 into molded wood flake part 12. The moisture content of the wood flakes 22 should be controlled within certain limits so as to obtain adequate coating by the binder during the blending step and to enhance binder curing and deformation of the wood flakes 22 during molding.

[0053] The presence of moisture in the wood flakes 22 facilitates their bending to make intimate contact with each other and enhances uniform heat transfer throughout the mat during the molding step, thereby ensuring uniform curing. However, excessive amounts of water tend to degrade some binders, particularly urea-formaldehyde resins, and generate steam which can cause blisters. On the other hand, if the wood flakes 22 are too dry, they tend to absorb excessive amounts of the binder, leaving an insufficient

amount on the surface to obtain good bonding and the surfaces tend to cause hardening which inhibits the desired chemical reaction between the binder and cellulose in the wood. This latter condition is particularly true for polyisocyanate binders.

[0054] Generally, the moisture content of the furnish after completion of blending, including the original moisture content of the wood flakes 22 and the moisture added during blending with the binder, wax and other additives, should be about 5 to about 25 weight percent, preferably about 8 to about 12 weight percent. Generally, higher moisture contents within these ranges can be used for polyisocyanate binders because they do not produce condensation products upon reacting with cellulose in the wood.

[0055] The furnish is formed into the generally flat, loosely-felted, mat 32, preferably as multiple layers. A conventional dispensing system, similar to those disclosed in U.S. Pat. Nos. 3,391,223 and 3,824,058, and 4,469,216 can be used to form the felted mat 32. Generally, such a dispensing system includes trays, each having one open side, carried on an endless belt or conveyor and one or more (e.g., three) hoppers spaced above and along the belt in the direction of travel for receiving the furnish.

[0056] When a multi-layered felted mat 32 is formed, a plurality of hoppers usually are used with each having a dispensing or forming head extending across the width of the carriage for successively depositing a separate layer of the furnish as the tray is moved beneath the forming heads. Following this, the tray is taken to the mold to place the felted mat within the cavity of bottom mold 28, by sliding the tray out from under mat 32.

[0057] In order to produce molded wood flake parts 12 having the desired edge density characteristics without excessive blistering and spring back, the felted mat should preferably have a substantially uniform thickness and the wood flakes 22 should lie substantially flat in a horizontal plane parallel to the surface of the carriage and be randomly oriented relative to each other in that plane. The uniformity of the mat thickness can be controlled by depositing two or more layers of the furnish (*i.e.*, wood flakes and binder) on the carriage and metering the flow of furnish from the forming heads.

[0058] Spacing the forming heads above the carriage so the wood flakes 22 must drop from about 1 foot to about 3 feet from the heads en route to the carriage can enhance the desired random orientation of the wood flakes 22. As the flat wood flakes 22 fall from that height, they tend to spiral downwardly and land generally flat in a random pattern.

Wider wood flakes within the range discussed above enhance this action. A scalper or similar device spaced above the carriage can be used to ensure uniform thickness or depth of the mat, however, such means usually tend to align the top layer of wood flakes 22, i.e., eliminate the desired random orientation. Accordingly, the thickness of the mat that would optimally have the nominal part thickness T (Fig. 3) is preferably controlled by closely metering the flow of furnish from the forming heads. The mat thickness that would optimally have the nominal part thickness T will vary depending upon such factors as the size and shape of the wood flakes 22, the particular technique used for forming the mat 32, the desired thickness and density of the molded wood flake part 12 produced, the configuration of the molded wood flake part 12, and the molding pressure to be used. However, as discussed above, felted mats 32 will be compressed to varying thicknesses by mold 20 due to unavoidable inconsistencies from mat 32, spring back, over-compression, or the like.

[0059] Following the production of the felted mat 32 and placement of the felted mat 32 within the cavity 30 of the mold 20, the felted mat 32 is compressed and cured under heat and pressure when the top mold die 26 engages the bottom mold die 28. Mat 32 is compressed preferably to a density of from about 40 to about 45 pounds per cubic foot, more preferably about 43 pounds per cubic foot. During this molding process, the extension 23 pushes through the binder coated wood flakes 22 of the felted mat 32 and is received by the extension receiving cavity 27. This action forms the slots 18 which defines the perimeter of flexible spring members 14. Any holes 34 will also be created during this molding step as detailed above.

[0060] The felted mat 32 is thus compressed and cured between the top mold die 26 and the bottom mold 28 to become the molded wood flake part 12. After the molded wood flake part 12 is produced, any flashing and any plugs are removed by conventional means to reveal flexible spring members 14 and holes 34.

MOLDED WOOD FLAKE ARTICLE DETAILS:

[0061] The process as described above can be used to fabricate three-dimensional articles, such as represented by the molded wood flake back 12 of chair 10 shown in Fig. 1. Back 12 includes integral flexible spring members 14, as more particularly described below. In particular, a molded wood flake article, such as back 12, is fabricated to include at least one flexible spring member 14 which is narrower then the width of the article in which the flexible spring member 14 is disposed. Flexible spring

member 14 is fabricated as a cantilevered member and more particularly as a cantilevered spring which can flex independently of the molded wood flake support.

[0062] Cantilevered flexible spring member 14 can be used in any article or situation wherein an independently flexible spring member is desired. For example, article 12 may be a molded chair back, as seen in Fig. 1, wherein one or more flexible spring members 14 are molded within the back. The discussion below, therefore, is directed to the furniture industry. This is, however, merely a preferred embodiment, and various other articles, both within the furniture industry and outside thereof, may be fabricated using the molded wood flake article with the inventive integrally formed flexible spring member.

[0063] In a first embodiment as shown in Figs. 1 and 4, molded wood flake article 12 comprises the back of a chair 10 including a seat 11 and the back 12, both coupled to each other and to chair legs 15 in a conventional manner. With respect to Fig. 4, back 12 includes at least one cantilevered flexible spring member 14 which can independently flex. In the preferred embodiment, a plurality of spaced-apart flexible spring members 14 are illustrated wherein each flexible spring member 14 can flex independently of each other as well as with respect to seat back 12. Flexible spring members 14 are fabricated by molding, machining, cutting or otherwise creating at least one slot 18 in molded seat back 12, thereby creating the at least one flexible cantilevered spring member 14 which is narrower than the width W (Fig. 4) of back 12. In the preferred embodiment, a plurality of longitudinal slots 18 are disposed vertically with respect to a vertical axis of seat back 12, and intermediate sides 17 and 19 thereof, to define a plurality of longitudinal flexible spring members 14 laterally disposed adjacently to one another. The flexible spring members 14 are connected, or more particularly integrally formed to the seat back, on base section 16 thereof, while the opposite ends on top 13 remain free to allow flexation of members 14. The free ends 13 of seat back springs 14 may optionally be covered by a sheath 130 of mesh material stapled in place as described in detail below in connection with Figs. 19 and 20. All of the seat backs of the various embodiments herein may optionally include such a sheath. Back 12 may be installed adjacent the rear of seat 11, as illustrated in Fig. 1, thereby providing a chair 10 which includes a flexible back member allowing a user to be comfortably seated therein.

[0064] The presence of flexible members 14 allow for turning movement to take place within the chair without having to move the seat thereof. Additionally, flexible

members 14 permit back portion 12 to conform to the shape of the user, thereby promoting greater comfort. Further, the back 12 and rear edge of seat 11, as well as flexible members 14, can be curved as shown in Fig. 1 to promote greater support. Further yet, flexible members 14 can be made any length, thereby offering the maximum flexibility and design characteristics which can be tailored as the specific requirements dictate.

[0065] In this embodiment, because the total weight disposed against back 12 is supported by a plurality of flexible spring members 14, the total load and/or deflection experienced by a given flexible member 14 will be divided over the total number of flexible members 14 supporting the weight.

[0066] The following equations define the expected amount of deflection and sheer stress that a given flexible member 14 should experience. In each equation n = number of flexible members.

$$D = \frac{wl^3}{3EI} \div n$$

$$\text{Sheer Stress } S_s \quad \text{(flexible member)} = \tfrac{3}{2}\,\frac{(load)}{2BH} \div n$$

where:

D = deflection;

w = 0.18 x (weight of user);

l = length or height of member;

E = elastic modulus of engineered wood;

I = moment of inertia;

B = member thickness; and

H = member height.

[0067] For the seat only, use the following formula to calculate deflection and to consider the different location of the weight of the user.

$$D_{seat} = \frac{W}{6EI}\,(2l^3 - 3l^2a - a^3) \div n$$

where:

D = deflection of flexible member (14A′, 14F, 14I);

$W = 0.82 \text{ x } W$, where W is the weight of user;

a = distance from the front end of spring member (*i.e.*, toward the back of the chair) to a point where the concentrated load is applied. This point is usually = 1/3 l.

[0068] Chair 10, and more particularly back 12, is fabricated from the aforementioned wood flake molding process. In the preferred embodiment flexible spring members 14 are integrally formed by molding appropriate slots or channels 18 into seat back 12 during the molding process. However, the channels 18 for flexible spring members 14 can be fabricated by numerous other methods, such as cutting, machining, sawing, or the like. Thus, when referring to the spring members as being "integrally formed" with a support, this refers to spring members which are integral with the surrounding support, such as base section or end 16 (Fig. 1), as opposed to being attached thereto by other means such as mechanical fasteners. The thickness of back 12 may range from about, preferably, ⅜ inch to ⅝ inch, and more preferably about ½ inch to 9/16 inch. Further, although flexible spring members 14 have been described with respect to back 12, a seat 11′ (Fig. 5) may also, either alone or in combination with back 12, incorporate flexible spring members 14 therein. Further, although the preferred embodiment of back 12 is fabricated separately from seat 11, both may be molded together in a single molding operation thereby creating a one-piece molded chair including a seat 11 and a back 12 wherein either or both portions may include flexible spring members 14 as illustrated in Fig. 6 (described in more detail below). As such, in the preferred embodiment, a robust yet flexible chair including independently flexible spring members, wherein the members can adjust to the seated user, has been created without adding any additional manufacturing steps or additional parts thereto.

[0069] Fig. 6 discloses an embodiment of the present invention in which a chair 40 has an integral seat 42 and back 44. Similar parts appearing in Figs. 1-5 and Fig. 6, respectively, are represented by the same, corresponding reference numeral, except for the suffix "A" in the numerals of the latter. With respect to Fig. 6, back 44 includes a plurality of flexible spring members 14A and seat 42 includes a flexible member 14A′, thereby incorporating the integrally formed flexible member in both the seat and the back, respectively, providing a dual cantilevered chair 40. Cantilevered seat 42 and its spring 14A′ and back 44 with channels 18A between cantilevered springs 14A are constructed in the same manner as previously described in connection with the seating

elements of Figs. 1-5. Back 44 and/or seat 42 may alternately include a single flexible member 14A or a series of spaced-apart flexible members, respectively. In this embodiment, the single spring member 14A′ is defined by a U-shaped channel 41. The chair form 40 may be covered by a suitable upholstery padding and fabric, as illustrated in phantom in the embodiment of Fig. 16, and is conventionally mounted to a base including one or more legs to define a completed chair.

[0070] Figs. 7 and 8 disclose another embodiment of the present invention with a chair 50 having a back 54 with single down-turned flexible spring member 14B. Similar parts appearing in Figs. 1-5 and Figs. 7-8, respectively, are represented by the same, corresponding reference numeral, except for the suffix "B" in the numerals of the latter. Chair 50 includes a seat 52 and a back 54 which includes the cantilevered flexible spring member 14B which can independently flex. As described above with respect to the first embodiment, flexible spring member 14B may be fabricated by molding, machining, cutting or otherwise creating at least one slot 51 in molded seat back 54. In the preferred embodiment, a pair of spaced-apart longitudinal slots 51 are disposed vertically with respect to the vertical axis of seat back 54 and intermediate to sides 53 and 55 thereof to define the flexible spring member 14B. Flexible spring member 14B is integrally formed to the back top end section 56 while the opposite end 57 of spring 14B remains free to allow flexation. In this embodiment, free end portion 57 is directed downwardly and forwardly to provide a flexible support for the lower back. In this embodiment, back 54 and seat 52 are attached to one another utilizing angle brackets 60, thereby providing an additional cantilevered spring for seat back 54. The chair 50 also conventionally includes legs 58 which are secured to seat 52 in a conventional manner. Seat 52 and back 54 can both be molded of wood flakes in the process described earlier.

[0071] As seen in Fig. 8, cantilever flexible member 14B displays two modes of cantilever action. Main back sections 59 on either side of spring 14B display a main deflection D1 relative to seat 52, while flexible member 14B displays a smaller deflection D2 relative to back sections 59. The deflection of each main section 59 and flexible member 14B can be calculated using the same basic set of cantilever beam equations.

$$D = Wl^3/3EI \div n$$

where:

D = deflection;

W = 0.18 x (w) where w is the weight of user;

l = length or height of member;

E = elastic modulus of engineered wood;

n = number of springs (n=1 in Fig. 8); and

I = moment of inertia,

and

$$I = BH^3/12$$

where;

B = member thickness; and

H = member height.

[0072] As can be seen from the above equations, D1 and D2 will vary relative to one another based solely upon their effective length or height, as all other variables are the same for each equation. The potential total deflection of flexible member 14B is determined by adding D1 and the opposite direction D2 together. Their effects are cumulative because main back sections 59 act as a secondary floating cantilever. Chair 50 also can be upholstered, as shown by the upholstery and padding shown in phantom in the embodiment of Fig. 16 or as seen in Fig. 9.

[0073] Fig. 9 illustrates a further embodiment of chair 50 including a foam pad 62 which provides an additional spring member, wherein the combined operation of flexible member 14B and foam member 62 provides chair 50 with ample lumbar support and comfort for a user seated thereon. Additionally, a foam cushion 64 covered by a layer of fabric 65 is also provided to complete back 54 of chair 50.

[0074] The chair 50´ of Figs. 10 and 11 is another embodiment of the present invention having a single down-turned forwardly extending flexible spring member 14C. Since chair 50´ is similar to the previously described chair 50, similar parts appearing in Figs. 10-11 are represented by the same, corresponding reference numeral, except for the suffix superscript (´) in the numerals of the latter. Chair 50´ includes a seat portion 52´ and a back 54´ which includes a cantilevered flexible spring member 14C which is formed to extend outwardly from the plane of the seat 54´ back toward the seat 52´. It independently flexes and creates a lumbar support to provide a more supportive lower back structure.

[0075] Fig. 12 generally designates a chair 70 which is another embodiment of the present invention and has a downwardly extending flexible spring member 14D. In this embodiment, chair 70 includes a seat and back 74 molded and joined in a manner similar to the chair shown in Figs. 1-4. The chair includes support legs 75 extending from seat 72. The back 74 of chair 70 includes a single flexible spring member 14D with a free end 77 which terminates into main section of back 74. Spring 14D is defined by a generally U-shaped channel 78 formed in back 74. This design provides a somewhat stiffer but yet flexible back to the chair. The back 74 is concavely formed, as is spring 14D, to comfortably receive a person's torso, although in some embodiments a straight back with a similar spring 14D may be preferred.

[0076] In the embodiments described above, the springs are formed from the molded wood flake material preferably by integrally molding channels to define one or more springs. The channel or channels typically have a width of about ½ inch, while the thickness of the cantilevered spring material is from about 3/8 inch to about 5/8 inch. Frequently, when springs are made for seating, such as shown in Fig. 5, the springs will be secured to a box-like framework defining, for example, a chair base to which legs and a back are subsequently attached, typically using fasteners such as threaded fasteners.

[0077] A sofa 80 embodying the present invention is shown in Figs. 13 and 14. The sofa or wide chair 80 includes a seat 82 and a back 84 which includes a plurality of cantilevered flexible arcuately shaped spring members 14E which can independently flex and are designed to replace the metal springs that have been used in the prior art. As illustrated, arcuate flexible spring members 14E include connected lower ends 81 which are attached, affixed or integrally formed with a base support 83. Spring members 14E have free ends 85 which terminate and rest on a foam pad member 86 attached to a vertically extending back member 87. Foam member 86 further enhances the spring effect and quality of flexible spring members 14E and is made of a high density foam which is glued or otherwise affixed to back member 87. As such, foam member 86 prevents any potentially damaging contact between molded wood flake springs 14E and back member 87, as well as provides an additional spring element for enhanced support. Foam member 86 and back member 87 may be omitted to provide a plurality of ends 85 which are free to flex as described in the previous embodiments.

[0078] In the preferred embodiment of a sofa back 84, interconnecting each flexible member 14E and located approximately • to ½ of the distance up from base 83 is lumbar foam support 88. Lumbar foam support 88 is connected by a suitable adhesive to each of the plurality of flexible members 14E and couples the springs to one another to provide co-joint back support and offers the additional advantage of providing a lumbar support for the back of a user. Additionally, a foam sheet 89 covers flexible members 14D and lumbar foam member 88. Foam material 89 is formed from a flat sheet of foam, which is relatively inexpensive as it does not need to be pre-shaped or provided with a particular contour. During the course of mounting material 89 in place with fabric covering 90, it takes the appropriate shape needed. An additional advantage associated with foam material 89 is that is can be manufactured to any desired size and length and/or can be cut from a larger sheet of foam. The "cushiony" feel provided by the combination of foam sheet 89, lumbar foam member 88, top foam member 86 and flexible members 14E eliminates the need for batting to achieve the desire degree of softness. This is especially advantageous since the elimination of the batting between the foam slab and the fabric reduces the material and/or labor costs of constructing sofa back 84.

[0079] In a preferred embodiment, a single foam member is used for members 86 and 88 which extends across flexible members 14E. These members may be fabricated from numerous materials which are commonly known within the art. However, the type of foam ideally used is a 2.5 – 3.0 pound foam. Base 83 and back member 87 may also be molded of wood flake material and may include support blocks 92 (Fig. 14) at spaced locations along their junction 94 for adding rigidity to this connection. Base member 83 is suitably secured to seat 82 by conventional brackets or by extending back member 87 below member 83 and coupling the back member to a seat forming support member which, as noted above, can also include the spring construction of this invention. Although not illustrated in Figs. 13 and 14, it is to be understood that molded wood flake springs could also be employed for seat 82 as in the design of Fig. 5 or the seat of Fig. 6.

[0080] Figs. 15 and 16 show an alternative embodiment of an article, such as a chair 100, in which the molded wood flaked seating section 110 integrally includes a front lower section 112 forming part of the chair frame. As best seen in Fig. 16, member 110 includes cantilever spring members 14F which are spaced from one another by

integrally molded channels 118 having a width of approximately ½ inch. The channels extend downwardly into the vertically extending section 112 and terminate in a circular aperture 114 which serves as a stress relief member for the cantilevered springs 14F extending from the vertical base section 112. The apertures for a channel width of ½ inch are approximately ¾ inch in diameter and preferably are integrally molded by employing a mold insert during molding of chair base 110. In some embodiments, however, it may be desirable to drill the circular apertures 114. The chair base is completed by a pair of molded wood flake sides 102 and 104 and a back member 106. Sides 102 and 104 include downwardly depending slots 105 which receive the integrally wood flake molded chair back 120, as seen in Fig. 15. The back 120 includes a notch 121 on each of the corners such that the back can extend into notches 105 in side members 102 and 104, allowing the interlocking of the back to the side members and allowing fastening screws 101 to extend through the apertures 103 to secure the back to the side members 102 and 104, as seen in Figs. 16 and 17.

[0081] The back 120 likewise includes three integrally molded spring members 14G which are defined by channels 108 extending therebetween downwardly to the integral lower section 122 of back 120. The sides 102 and 104, back member 106, seat section 110, and seat back 120 are secured to one another by threaded fasteners 101 which extend through the apertures 103 formed at various locations in the respective members, as best seen in Fig. 15, for securing the seat elements together, as illustrated in Fig. 16. Thus, in the embodiment shown in Figs. 15 and 16, the chair base includes an integrated wood flake molded section which integrally forms a frame member for the bases. Each of the members 102, 104, 106, 110, and 120 are molded utilizing a wood flake mat, such as mat 32 shown in Fig. 2, and a suitable mold configuration in the process identified above. The chair 100 may include a suitable fabric and upholstery covering 113, shown in phantom in Fig. 16, and, of course, support legs 117 conventionally coupled to the frame forming elements of the chair base (*i.e.*, 102, 104, 106, 112).

[0082] The chair design, as shown in Figs. 15 and 16, can be modified as shown by chair 100′ in Fig. 17 by providing a back member 106′ which extends upwardly approximately midway through the back panel 120 and which includes a foam pad 124 which extends behind the cantilevered spring members 14G of back 120 to provide additional support for the back 120. The foam pad 124 can have a density of from 2 ½ to 3 pounds and is bonded to the back member 106′ and the back surface of spring

members 14G by suitable bonding agents in a conventional manner. The foam block 124 extends substantially the width of back 120 and interconnects the cantilevered springs 14G to one another to allow cooperative bending of the seat back upon application of pressure from a person's back. In both embodiments of the chairs shown in Figs. 15-17, the outer spring members 14F are spaced from the respective side panels 102 and 104 to allow clearance and flexure of the two outermost spring members. Likewise, the free ends of the spring members 14F are spaced from the lower section 122 of back 120 to allow their flexure without contacting the seat back.

[0083] Fig. 18 illustrates an alternative embodiment of a similarly formed chair 100´´ with the corresponding elements identified with the same reference numeral as those used in Figs. 15-17. The chair 100´´ differs in that the base 110A has a plurality of tapered springs 14H which taper inwardly in a rearward direction as seen in Fig. 18. This construction provides spring members 14H for the seat 100´´ which has a softer, less stiff feel than the substantially uniform 2 inch wide spring fingers 14F of the previous embodiments. As in the previous embodiments, the seat section 110A includes an integral frame member 112 and channels 118A, which are configured to define the inwardly, rearwardly tapered spring members 14H. Thus, channels 118 are generally elongated triangular channels, as best seen in Fig. 18, to define the tapered spring arms 14H. Although in the embodiment shown in Fig. 18, the taper of arms 14H begin approximately midway toward the rear of the seat 110A, the tapers can start near the bend 111 between the horizontally extending fingers 14H and the generally vertically extending integral frame member 112.

[0084] Figs. 19 and 20 illustrate a further improvement to the chair design 100 of Figs. 15 and 16 by which the free floating ends of spring members 14G forming the seat back 120 are intercoupled by an elastomeric mesh 130 which is fitted over the free ends of spring members 14G and stapled to the outermost of the spring members, as shown in the cross section of Fig. 20, by staples 132 to loosely couple the ends of spring members 14G to one another such that the deflection of members 14G will co-jointly affect one another. In Figs. 19 and 20, sheath 130 had a length "L" of approximately 2 to 3 inches and covered the upper and lower surfaces of the free ends of spring arms 14G. Sheath 130 tends to prevent overstress of individual spring members 14G and limit the overall action of the springs. The sheath 130 is an open mesh elastomeric stretch material made of polyester or vinyl. One webbing which has been used is

commercially available from Bruin Plastics Company, Inc. as 9x9 vinyl coated mesh. Although the sheath 130 in the embodiment shown in Figs. 19 and 20 extends around the free ends of the spring members 14G, in some embodiments it may be desirable to provide the mesh at other locations, such as by providing wrapping around the spring members 14G near the midway of the seat back to likewise loosely intercouple the springs together. Sheath 130 also serves to contain the free ends of spring members 14G in the unlikely event one of the spring members should fracture during use, thereby substantially maintaining the integrity of the seat base in such an event.

[0085] Another modification to the chair 100 shown in Figs. 15 and 16 is illustrated in Figs. 21 and 22 in which the chair 100 includes an underlying support web of elastomeric material 140 which can be stapled to the side members 102 and 104 of the chair base by staples 142. One or more strips of webbing 140 can be positioned, as seen in Figs. 21 and 22, at suitable locations, such as midway in the seat 110 to underlie and provide additional support across and under spring members 14F. The attachment of web 140 under the seats can be selected to move forwardly or rearwardly depending upon the feel desired for the seat section 110. In some cases, it may be desirable to provide an adjustable intercoupling of the attachment of web 140, as shown by the pictorial diagram of Fig. 23.

[0086] In Fig. 23, a movable attachment member 145 is provided for the webbing 140 and can be secured to the side members 102 and 104 by providing longitudinally and vertically extending slot 146 in the side members 102 and 104 and a suitable clamping structure 147 to secure member 145 and web 140 coupled thereto in a selected, vertically adjustable position, allowing for motion along a vertical axis Y (shown in Fig. 23) or in a horizontal direction X (shown in Fig. 23) to position the web 140 forwardly or rearwardly in seat section 110 and either in contact with the undersurface of fingers 14F or slightly spaced therefrom such that the spring members 14F can deflect initially without engaging supporting web 140. The clamp member 147 can be a pair of plates which engage opposite sides of side members 102 and 104 and which include suitable adjustment thumb screws 115 reachable from the inner side of side members 102, 104 such that the feel of the chair seat can be selectively adjusted by either the chair manufacturer or by the purchaser of the chair, if desired. Thus, depending upon, for example, the weight of the user , it may be desirable to have web 140 moved more rearwardly to provide a greater degree of support for the free ends of spring members

14F and into contact with the undersurface of the free ends of spring members 14F to provide maximum additional support. For a softer feel, the webbing 140 can be moved forwardly toward the front edge of the chair 100 and/or moved downwardly such that the spring member 14F can initially flex without engaging the supporting underlying web. The web may have a width along the X axis of about 3 inches and limits the deflection of the members 14F from about 20 to about 40 percent depending on the positioning of the web or whether one or more webs are used. One 3 inch wide web material which has been used is a polypropylene spiral wrap natural extruded rubber threads cross-woven with polypropylene thread which is commercially available from Ultraflex Corporation.

[0087] Fig. 24 shows an alternative embodiment of a chair 200 which is substantially identical to chair 100 shown in Figs. 15 and 16 with the exception that the seating spring members 14I each integrally include a concave reinforcing indentation 202 which extends from the front frame wall 212 rearwardly to the free end of each of the springs 14I. The indentations are molded into the seat section 210 together with the channels 218 which define each of the spring members 14I. As in the previous embodiment, the channels 218 terminate in a circular aperture 214 in the frame member 212, which is assembled as in the previous embodiment with side members 102 and 104 and a back member 120 having spring members 14G and formed by channels 108 as in the prior embodiments. The addition of indentations 202 increases the spring constant significantly to provide a much stiffer feel to the seat section 210. In one embodiment of the invention with a spring thickness of ½ inch and the width of the springs being from 2 to 3 inches wide, the indentations 202 were approximately ½ inch deep and 1 inch wide with no greater than a 3/8 inch radius at the corners 203 and 207 shown in Fig. 25.

[0088] In the above embodiments, a molded wood flake support member has been described which includes an integrally formed molded wood flake flexible spring. The flexible spring member acts as a cantilevered spring thereby flexibly supporting the user that is seated therein. The above embodiments have been particularly directed to the furniture industry and more particularly to the seating industry. However, these embodiments represent only the preferred embodiments and are not meant to be limiting in any manner. The above inventive integral flexible spring can be utilized in various

ways and be fabricated into varied articles. Hence, the above description is that of the preferred embodiments only.

[0089] Modifications of the invention will occur to those skilled in the art and to those who make or use the invention. Therefore, it is understood that the embodiment described above is merely for illustrative purposes and not intended to limit the scope of the invention, which is defined by the following claims as interpreted according to the principles of patent law, including the Doctrine of Equivalents.